Satellite images for offshore wind resources

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Satellite images for offshore wind resources

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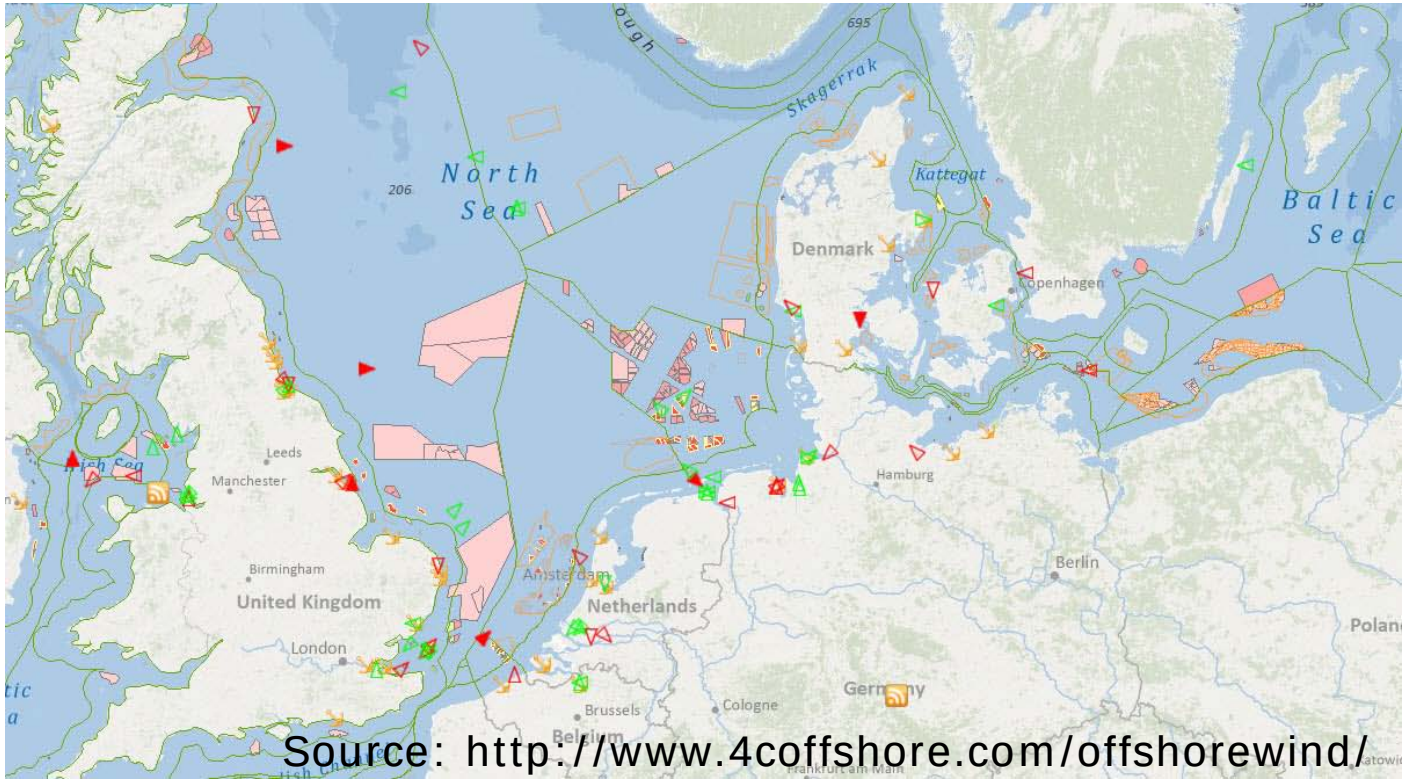
Department of Wind Energy

Korea Advanced Institute of Science and Technology (KAIST)-DTU Wind Energy workshop, Roskilde, Denmark, 20 Sept. 2012

Content

- Motivation
- Ocean wind from satellites
- Wind resources offshore
- Wind farm wake
- Summary

Motivation: Europe

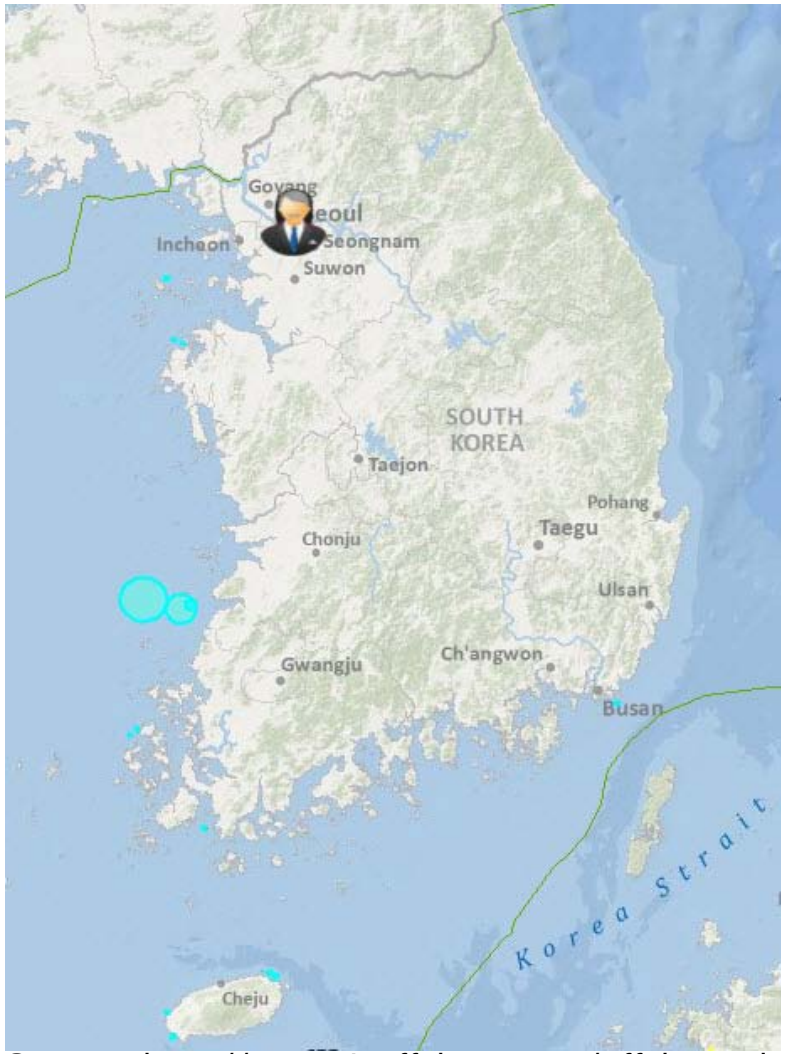


Source: http://www.4coffshore.com/offshorewind/

Information on winds necessary:

- Tall offshore meteorological mast, cost 10m£
- Wind lidar on platform alternative
- Floating wind lidar?
- Satellite ocean wind observations
- Modelling (microscale and/or mesoscale)

Motivation: South Korea



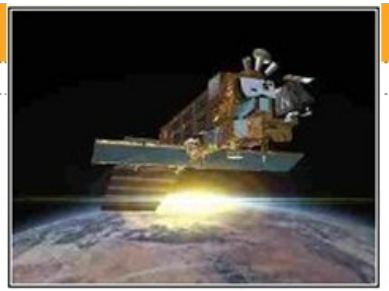
Source: http://www.4coffshore.com/offshorewind/

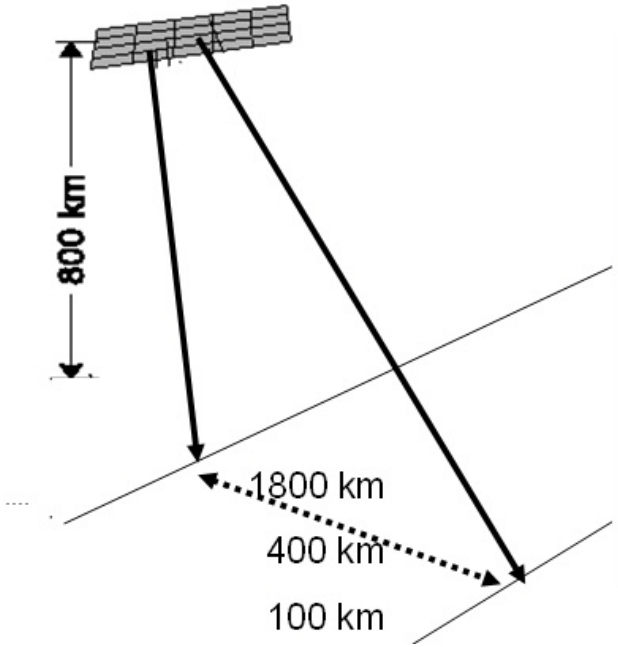
17 offshore wind farm projects with sum of 4 GW offshore capacity

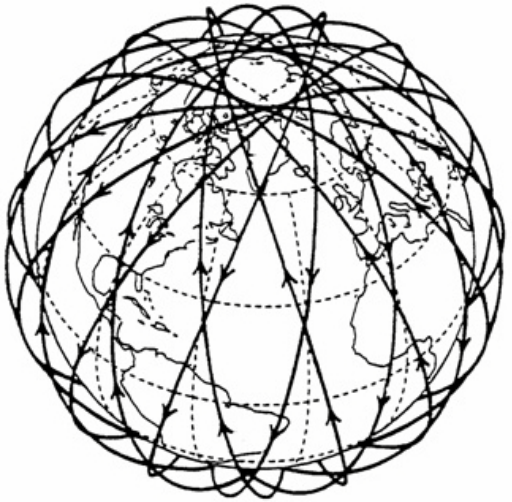
South Korea offshore wind farm plans

Wind farm	MW	Concept / early planning	Consent application sent	Under construction	Fully commissioned
Busan	350	1			
Daejeong-Phase 1	100	1			
Daejeong-Phane 2	100	1			
Dongyang	27	1			
Haengwon-ri	60	1			
Hall E&Offshore wind 1	100	1			
Hall E&Offshore wind 2	200	1			
Incheon Offshore Wind Farm	97.5	1			
Limjado	100	1			
Shinan	90	1			
Soutwest Offshore Wind project 1 (test)	100	1			
Soutwest Offshore Wind project 2	400	1			
Soutwest Offshore Wind project 3	2000	1			
Taean 1	97.2		1		
Taean 2	200	1			
Tamra Offshore Wind Farm	30			1	
Demo Jeju Island	5				1

Satellite principle - radar







ASCAT

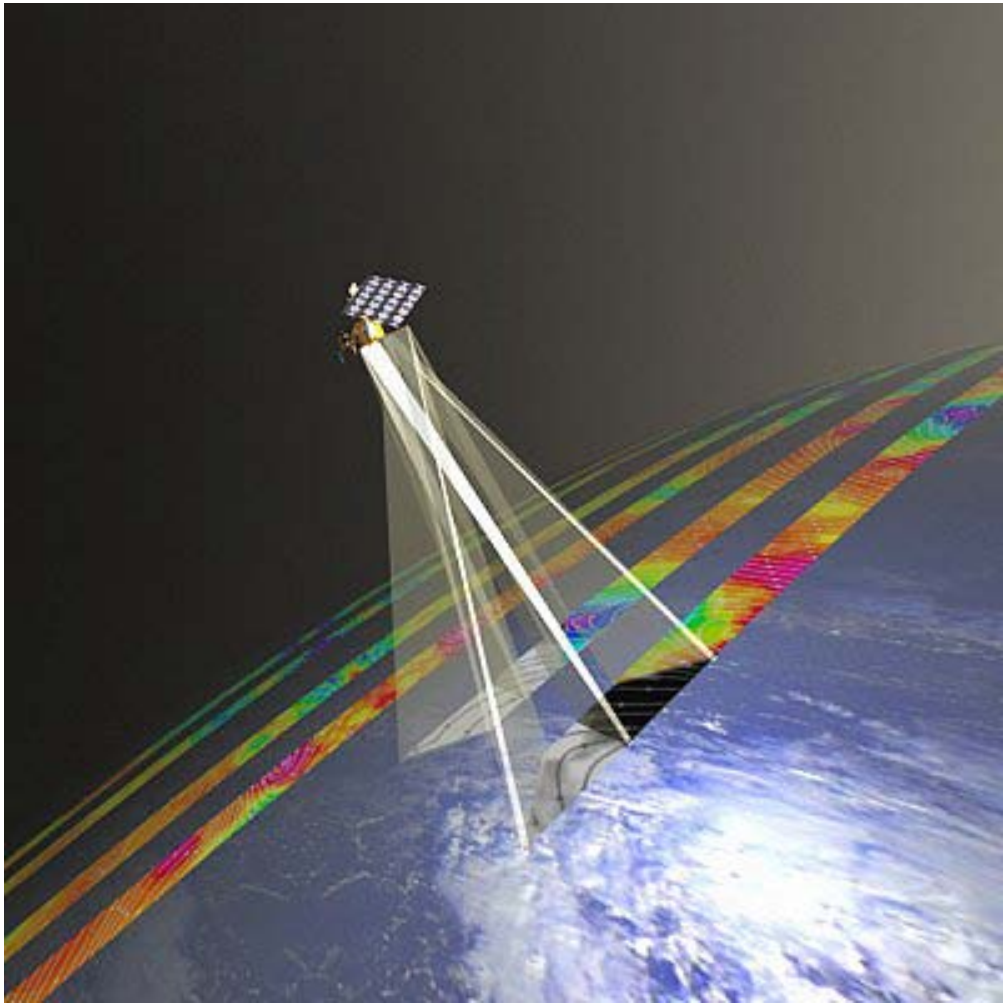
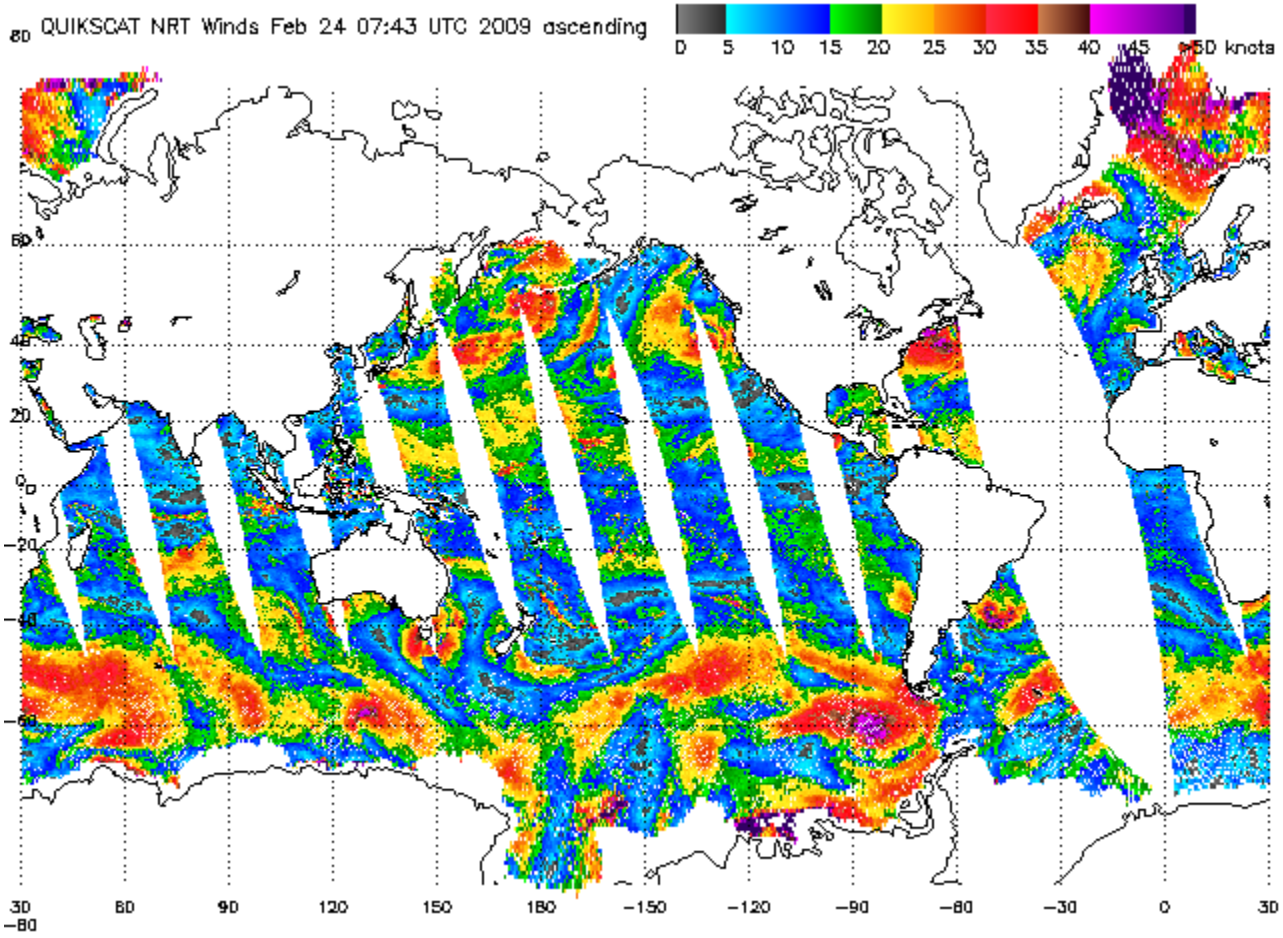
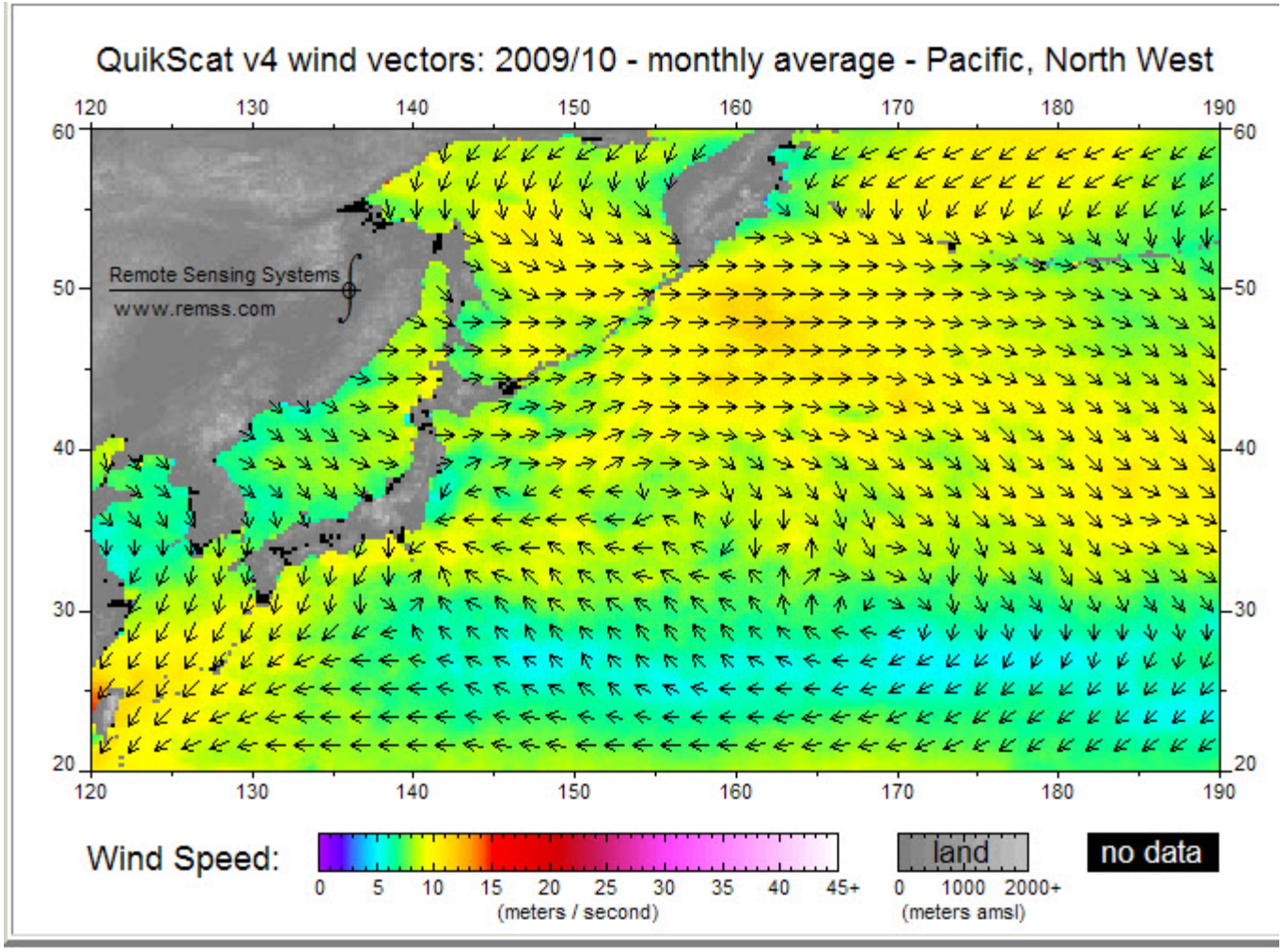


Image from ESA

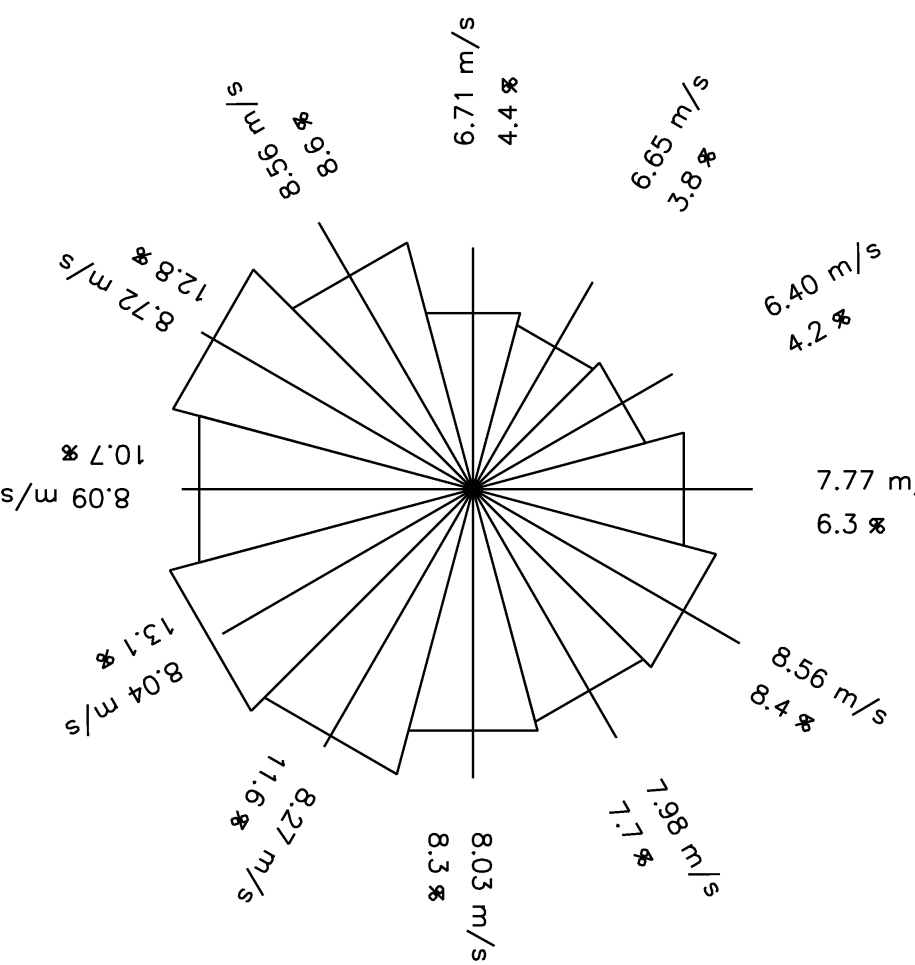
Scatterometer winds (QuikSCAT)



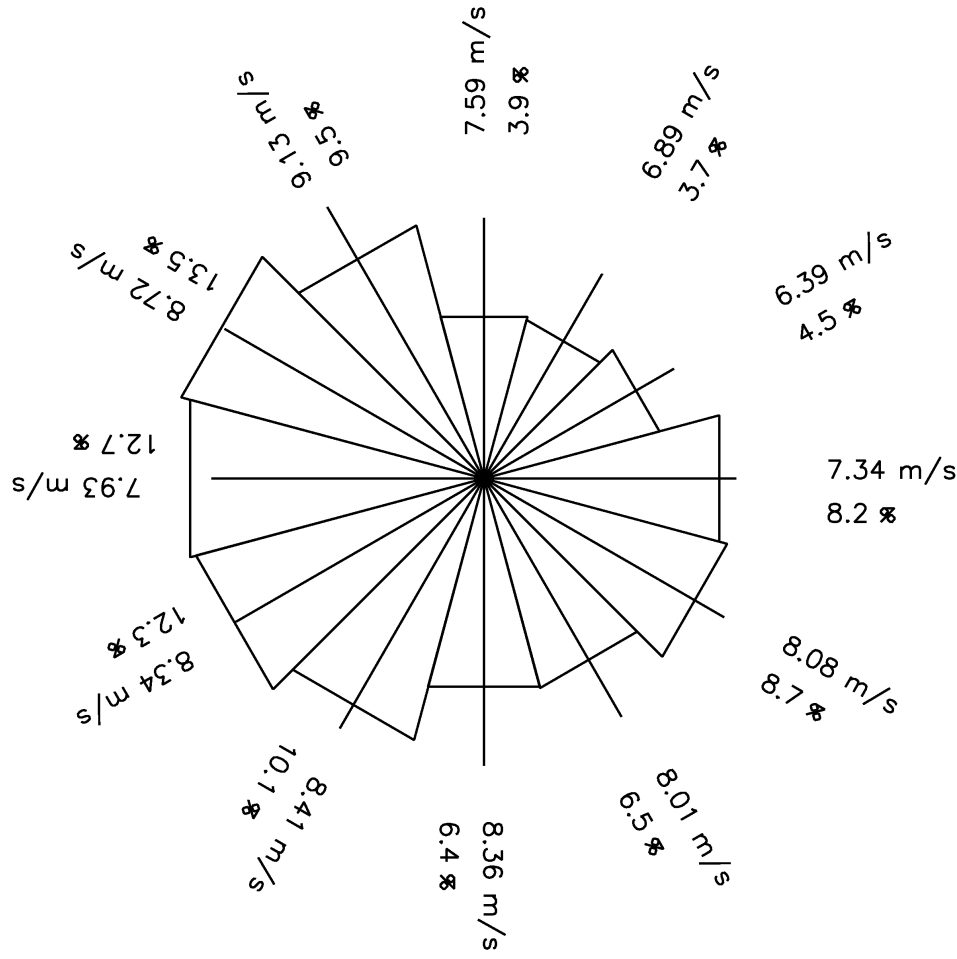
Monthly example from Pacific North West



Example mast and QuikSCAT at Horns Rev



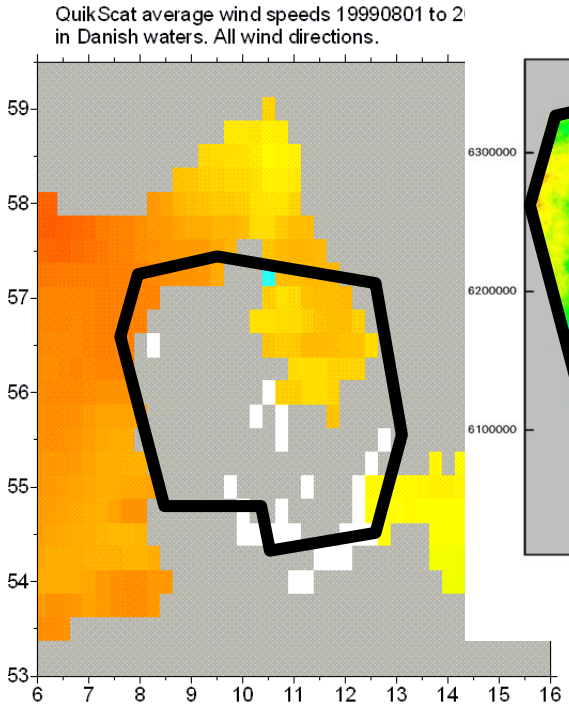
Mast data courtesy DONG energy



QuikSCAT

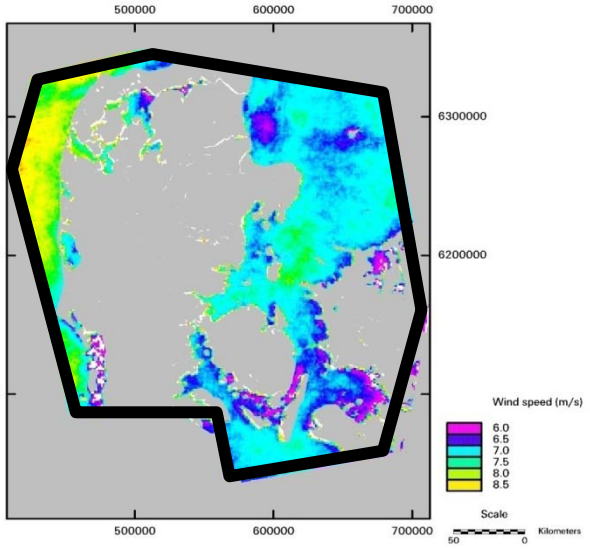
From Hasager et al. 2008 IEEE TGARS , vol. 1, 67-79.

QuikSCAT and Envisat ASAR resolution and coastal



QuikSCAT 25 km

1999

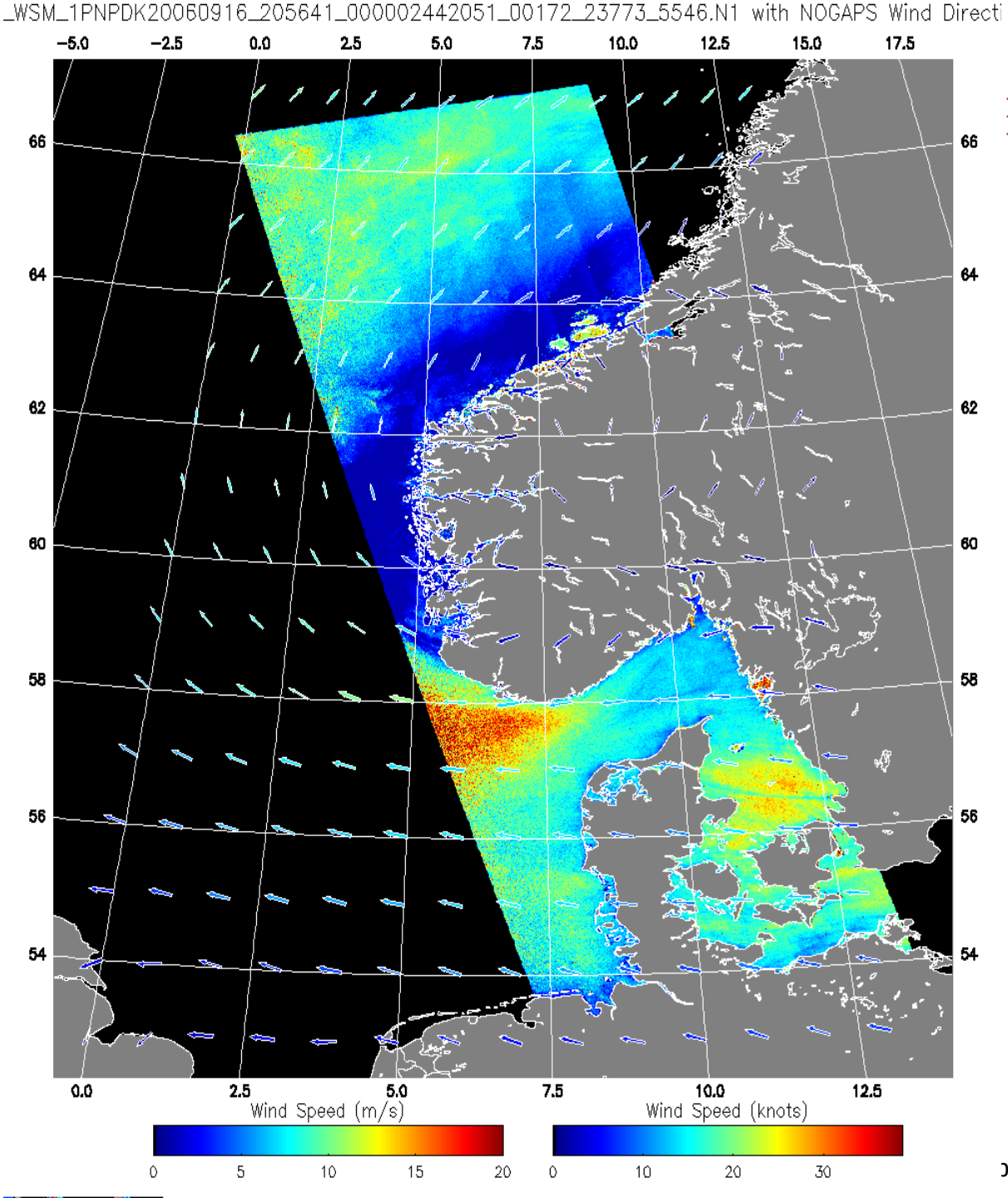


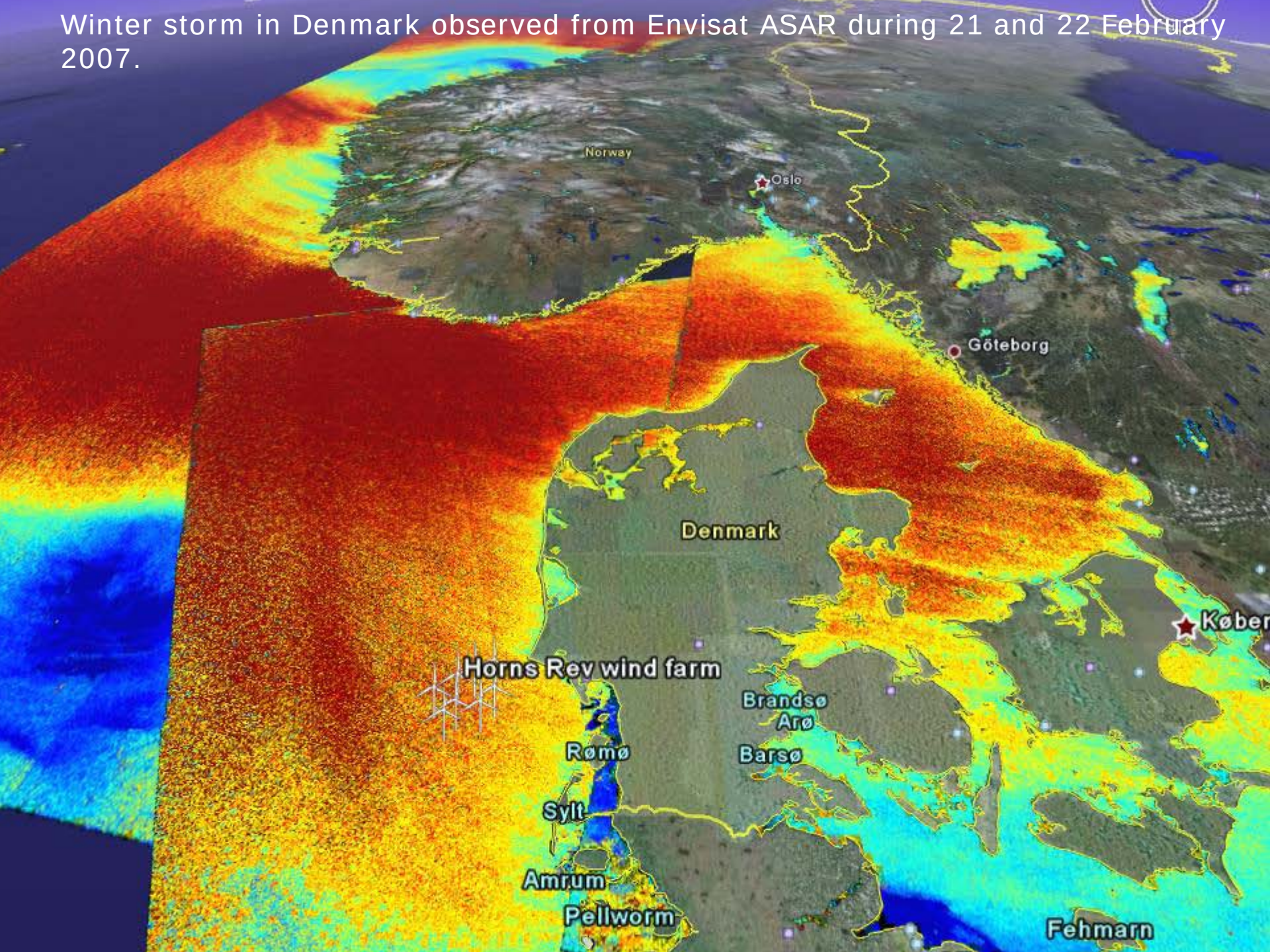
Envisat SAR 1 km

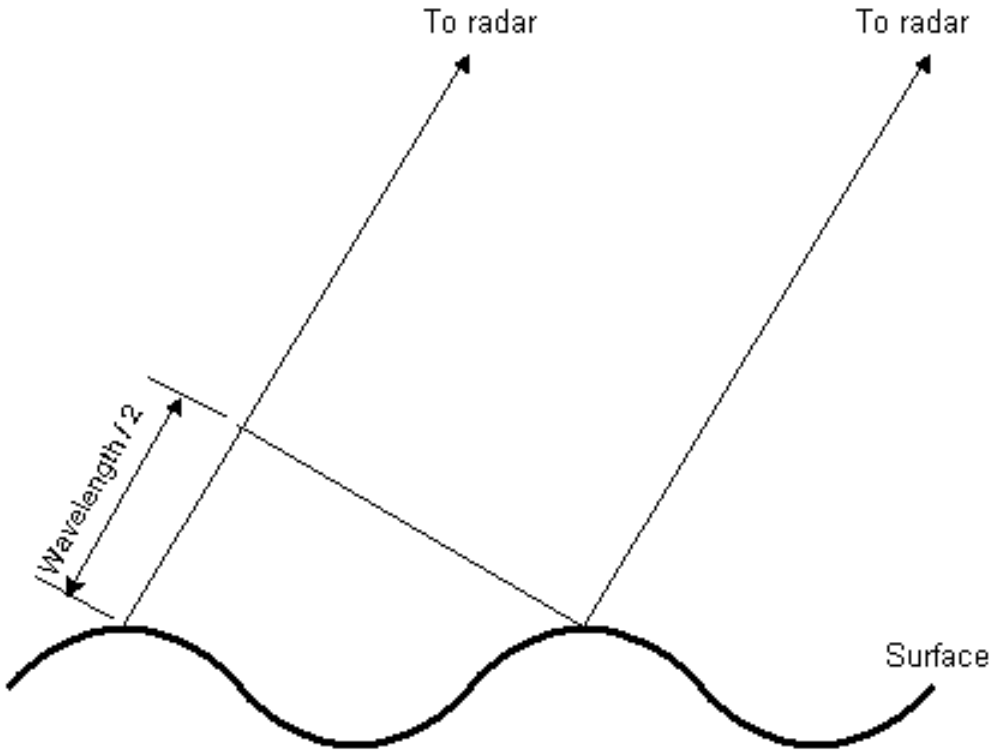
2002

Satellite SAR wind map

- Wind map covering Danish and southern Norwegian Seas based on Envisat ASAR WSM from 2006/09/16 at 20:56:41 UTC DTU Wind Energy/ JHU APL.




Winter storm in Denmark observed from Envisat ASAR during 21 and 22 February 2007.
Norway
Oslo
Göteborg
Denmark
Horns Rev wind farm
Brandsø
Arø
Barsø
Rømø
Sylt
Amrum
Pellworm
Fehmarn



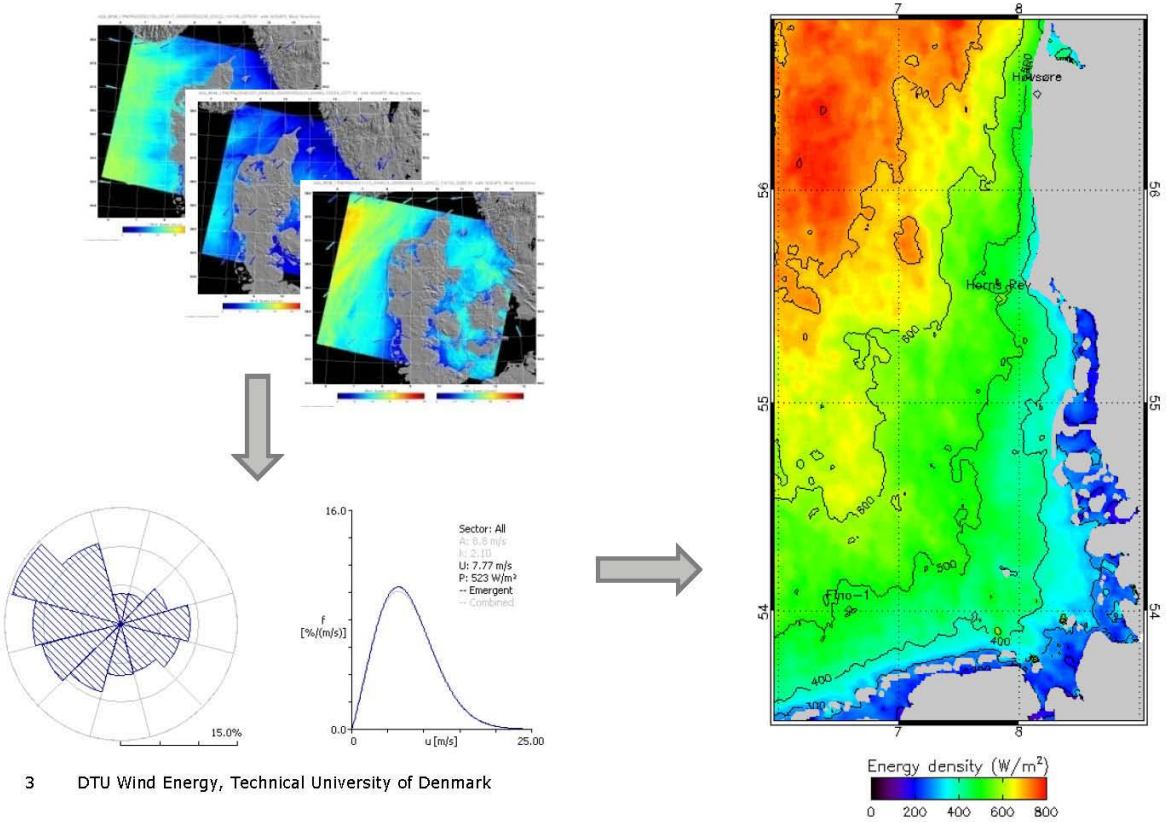
Physics

Ocean surface roughens by wind interaction: Capillary and short gravity waves are generated.

More wind causes more steep waves causes higher backscatter.

Offshore wind ressource method

Wind resource mapping from satellite wind fields



3 DTU Wind Energy, Technical University of Denmark

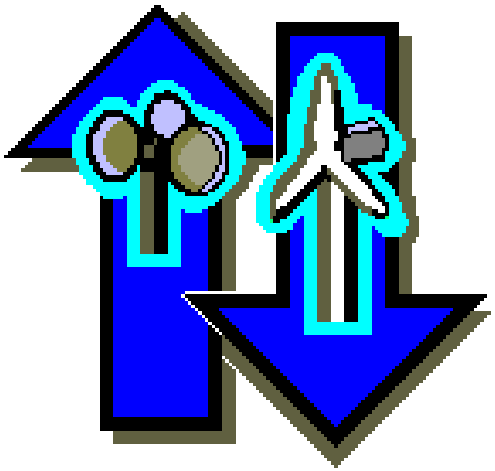
Results comparing SAR and three met masts

- Detailed wind ressource maps have been produced over a domain in the North Sea and compared to measurements at three sites in 4-yr period (2005-2008). The accuracy on mean wind speed and Weibull A was below 5% and below 7% for Weibull k and energy density.

- The model results from mesoscale modelling are typically around 5 to 15%.

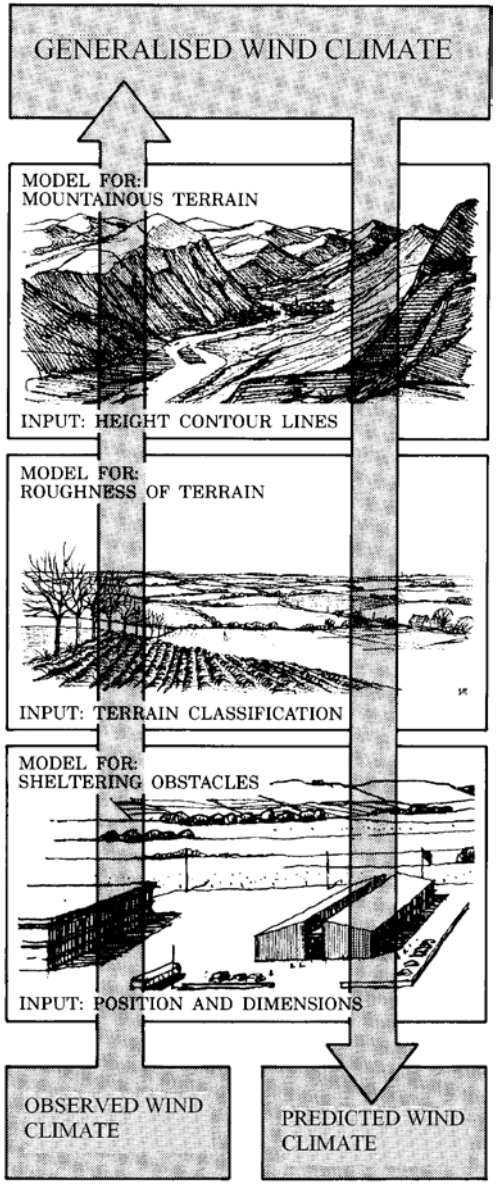
- Reference:
- Badger et al. 2010, Wind class sampling of satellite SAR imagery for offshore wind ressource mapping, J.Applied Meteorology and Climatology, 49, 2474-2491.

WAsP

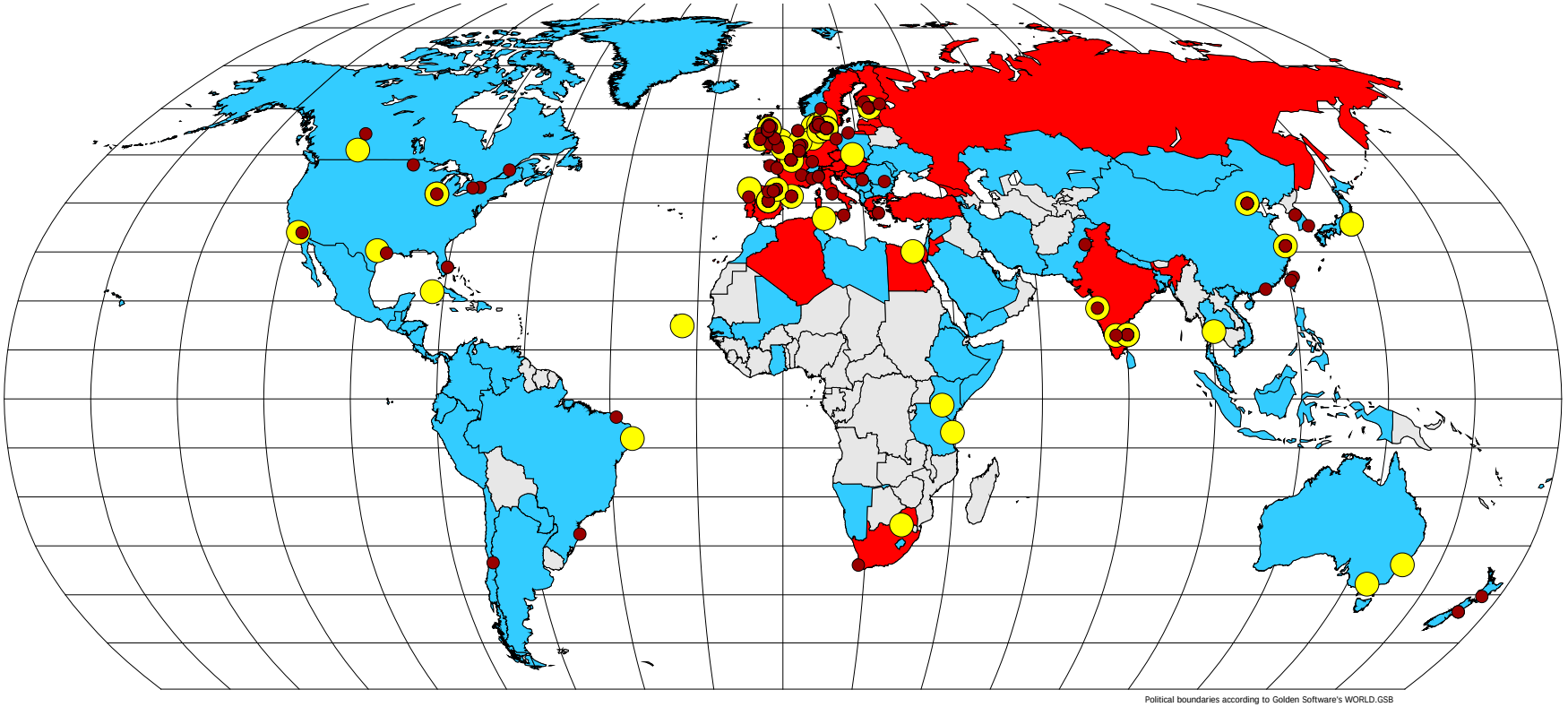


WAsP icon

www.wasp.dk



DTU Wind Energy: WAsP & WAsP Engineering

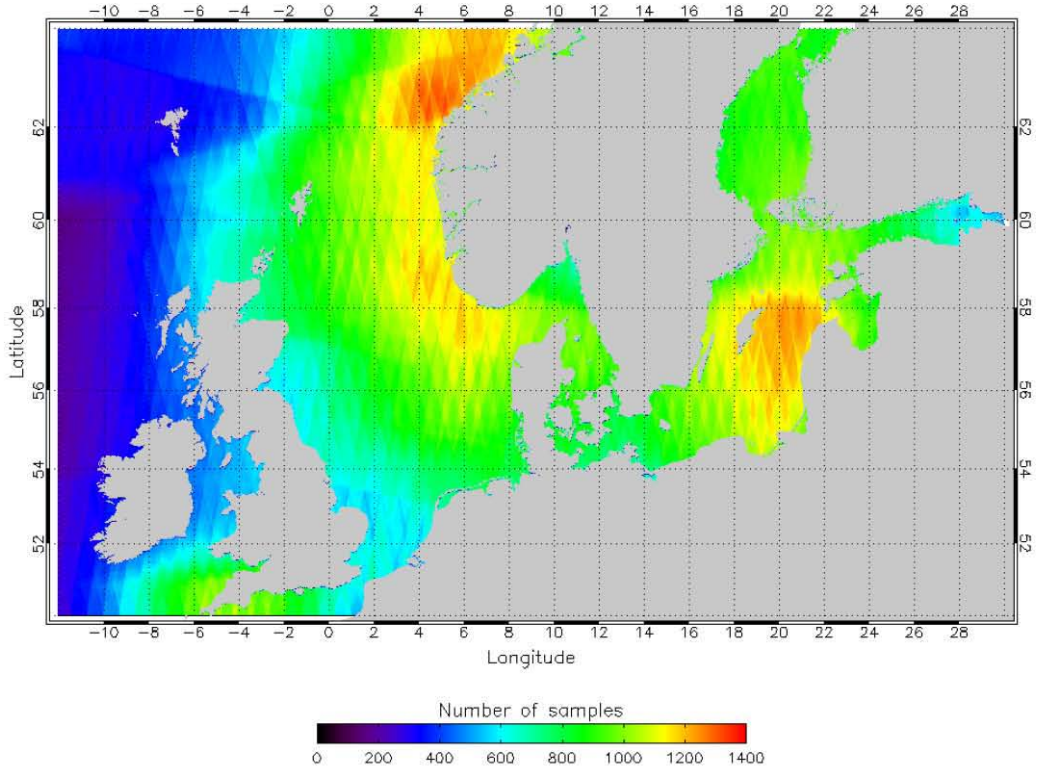


- WAsP/WEng software since 1987/2001
- More than 4000 licensed users
- Used in 110⁺ countries and territories

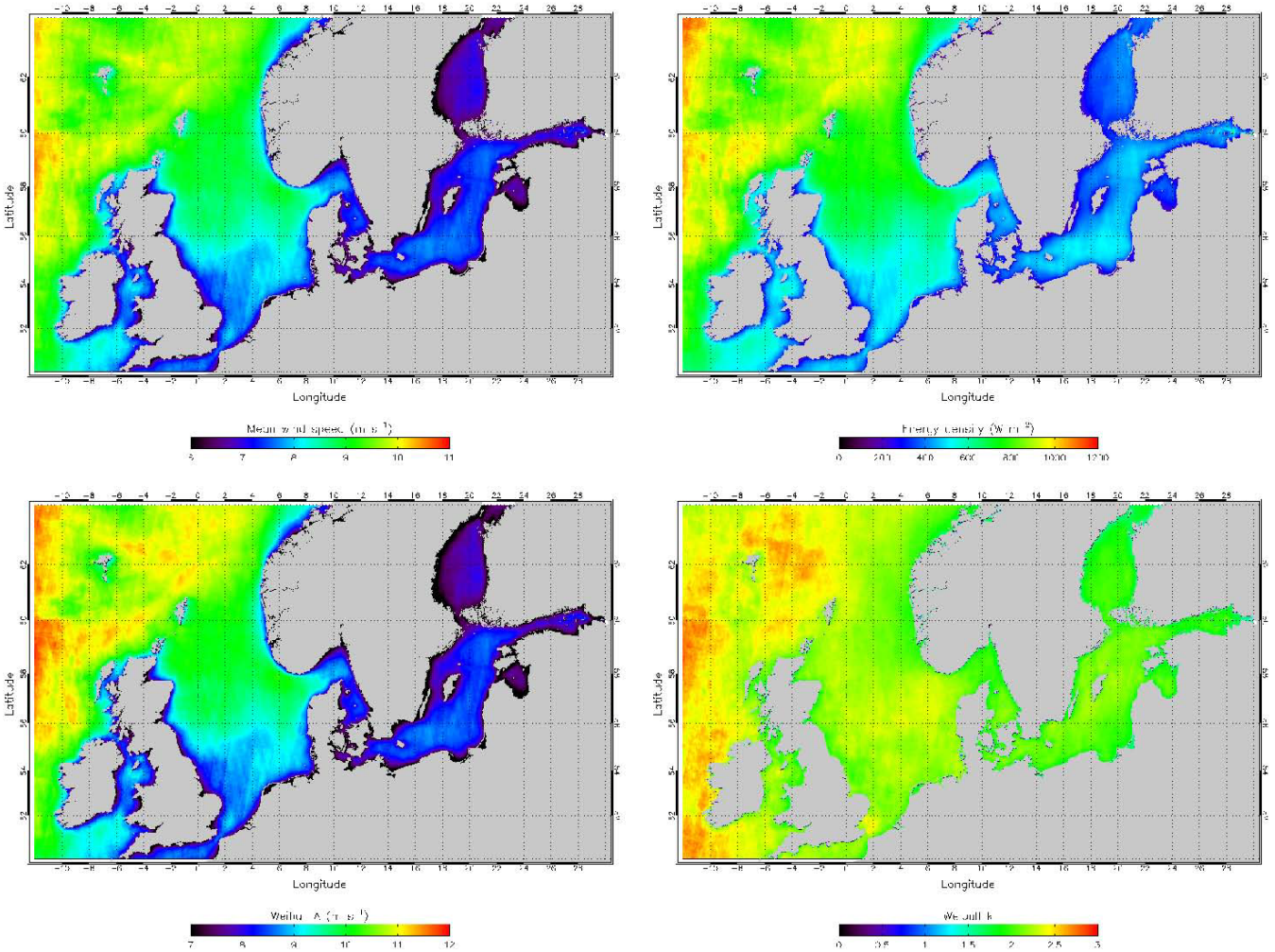
- WAsP/WEng courses since 1991/2001
- More than 100 courses in 25 countries ●
- 186 certified WAsP users in 27 countries ●

Example Northern European Seas

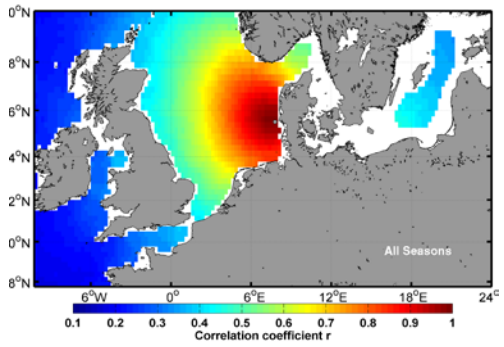
Envisat ASAR scenes in the NORSEWInD project - and the 10-m wind atlas from SAR

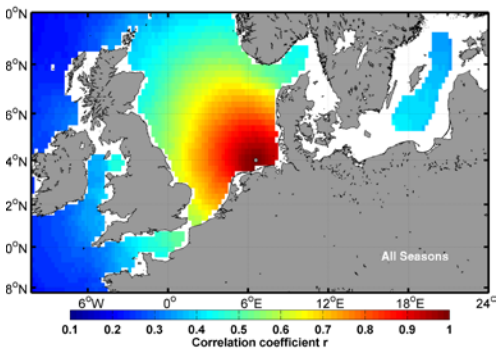


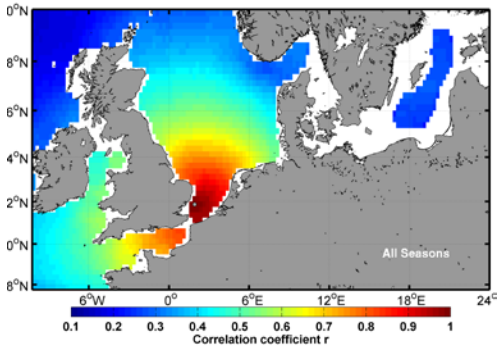
Northern European Seas from EU Norsewind project

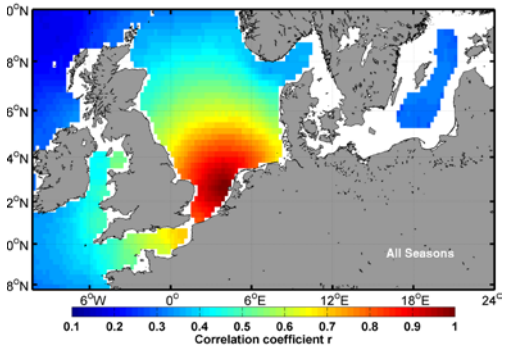


QuikSCAT – spatial correlations









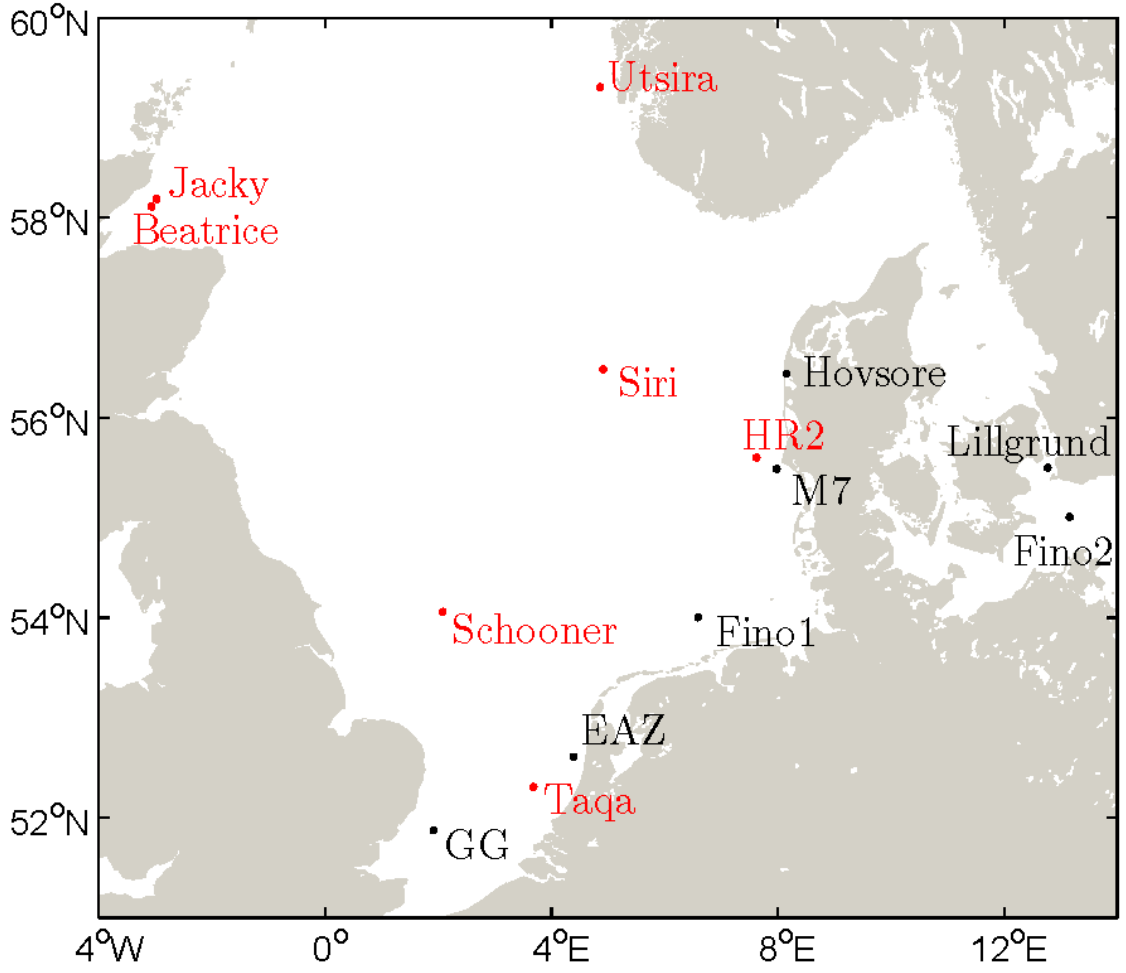
Horns Rev M2

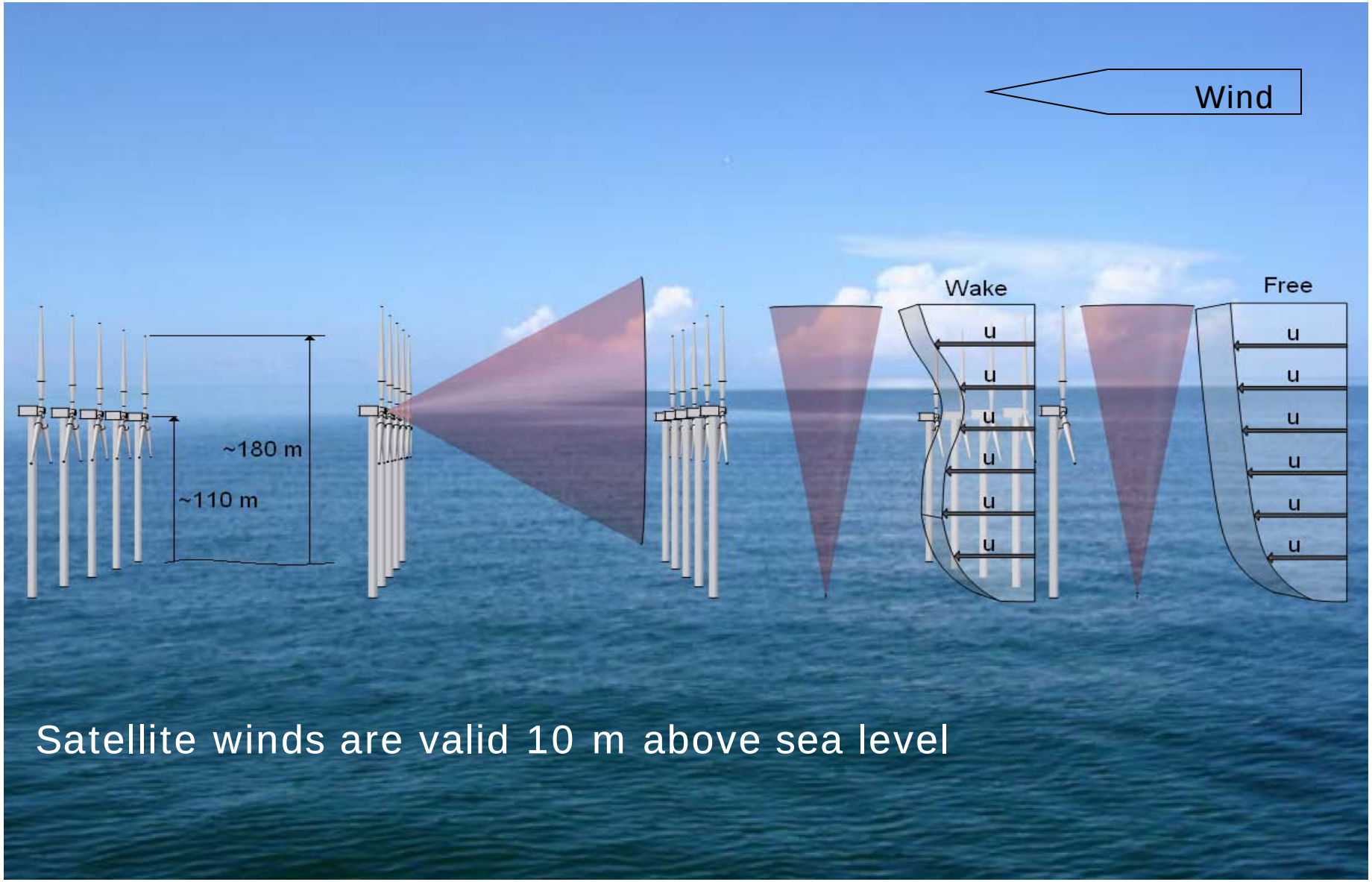
FINO-1

Egmond aan Zee

Greater Gabbard.

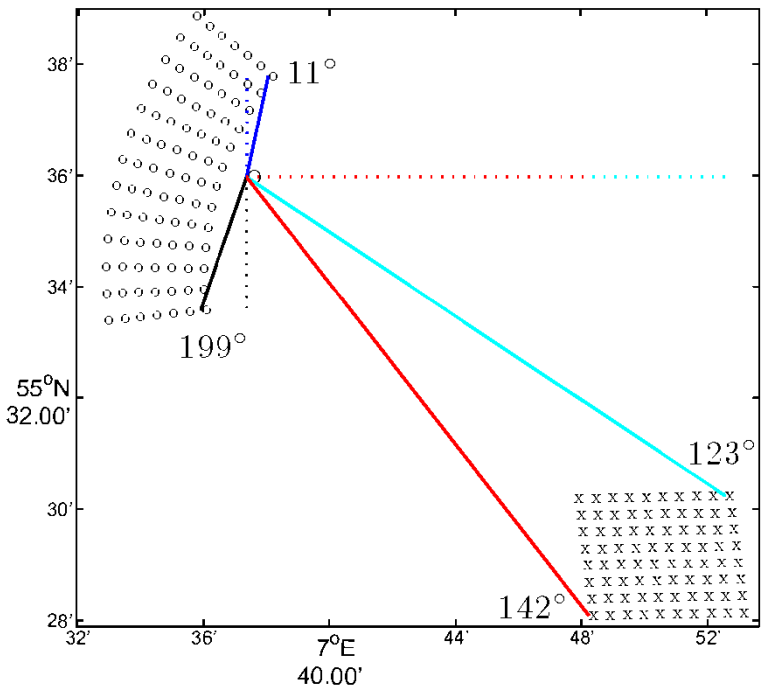
Norsewind installations

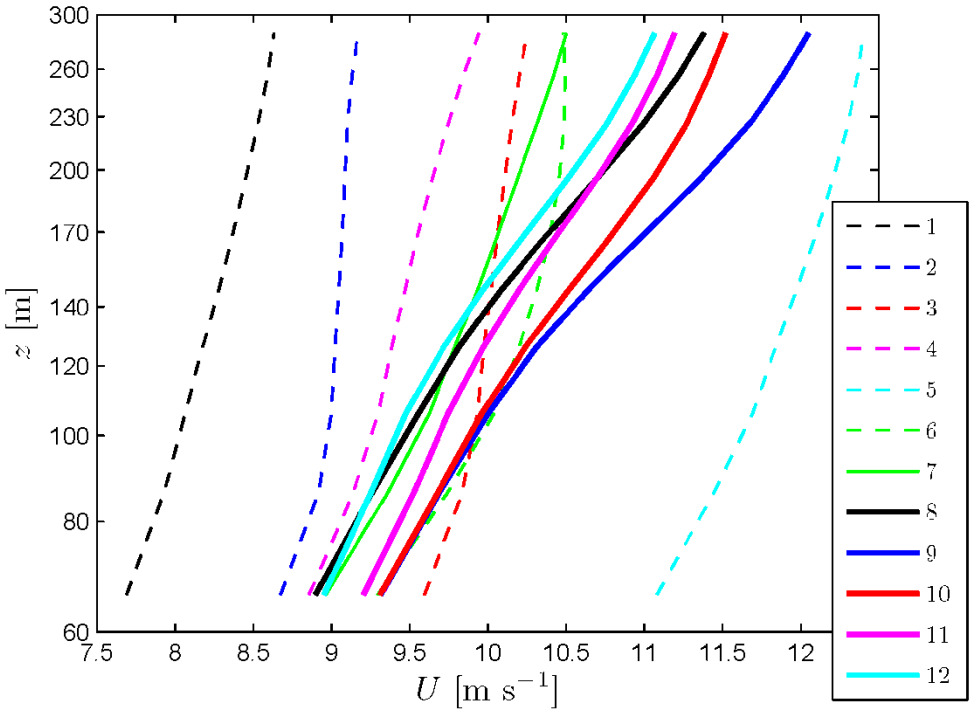




Satellite winds are valid 10 m above sea level

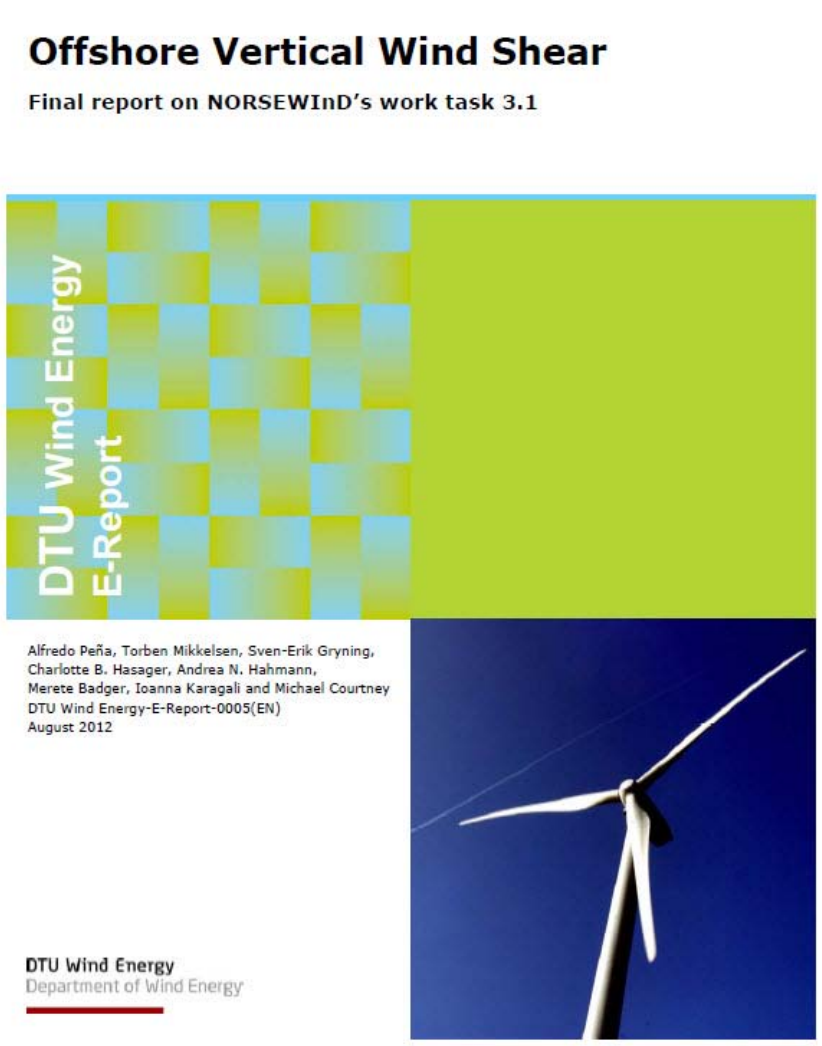
Horns Rev: layout and wind profiles from lidar





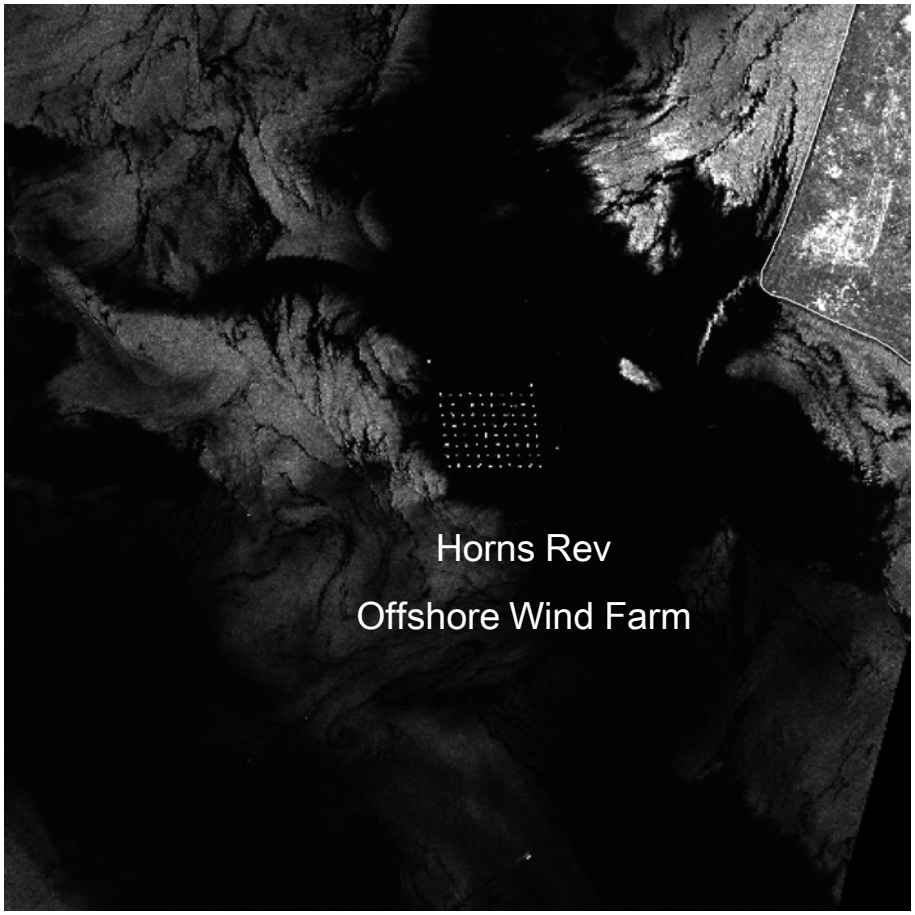
Courtesy data: DONG energy, analysis Alfredo Peña, DTU Wind Energy

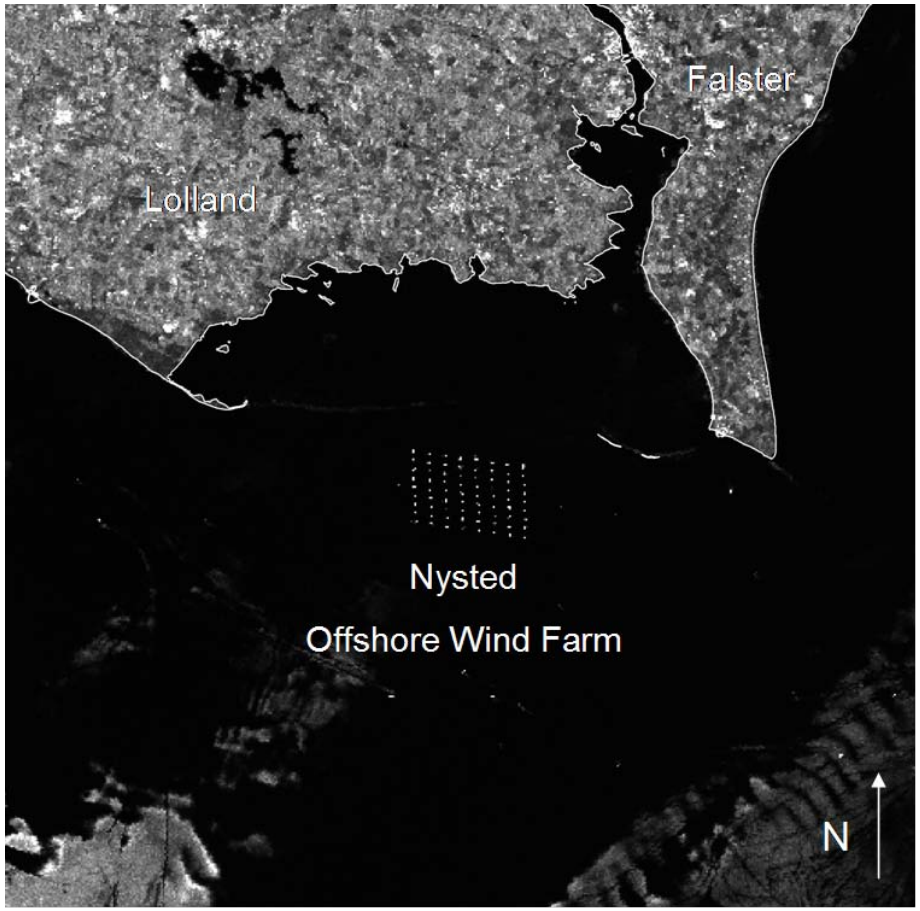
Two recent reports from DTU Wind Energy



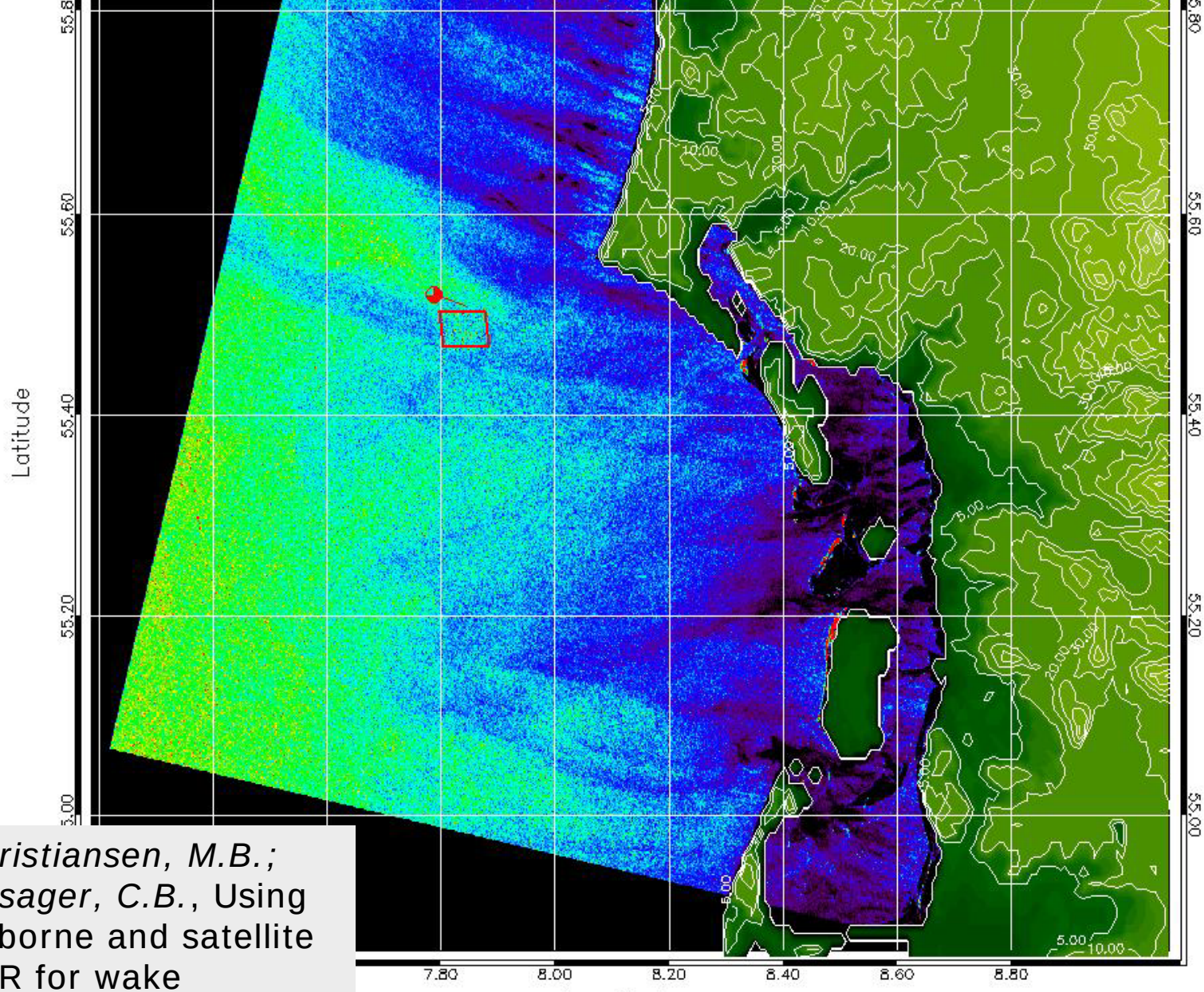
Wind farm wake

Wind farms seen from satellite





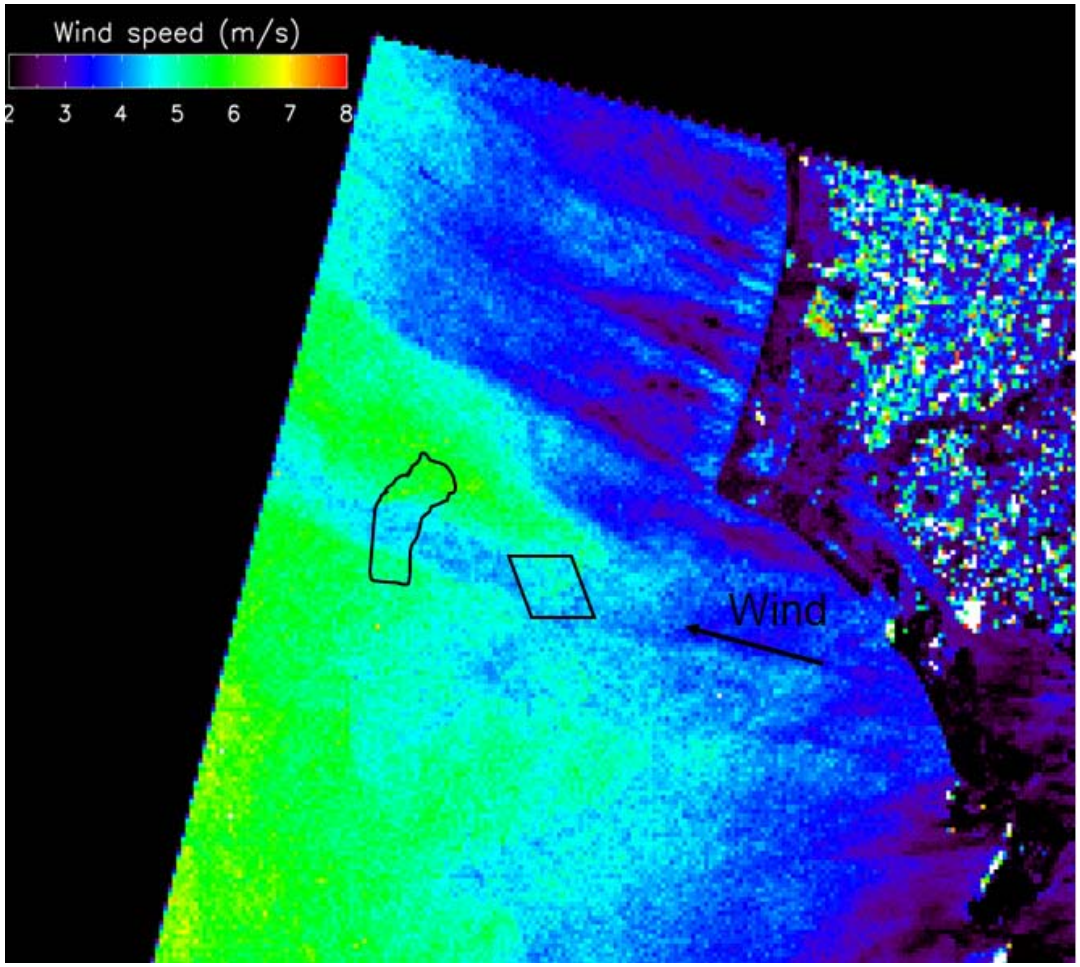
ERS-2 images, 50 km x 50 km (no wind)



Wind field from ERS-2 SAR

Christiansen, M.B.; Hasager, C.B., Using airborne and satellite SAR for wake mapping offshore. *Wind Energy* (2006) **9** 437-455

Wind farm wake – two wind farms?



Design Tools for Offshore wind farm Clusters

www.eera-dtoc.eu

Summary

- Scatterometer ocean vector winds from QuikSCAT and ASCAT are medium resolution and not very close to coasts but long-term data set
- Satellite SAR ocean vector winds from Envisat and later Sentinel-1 (ESA/EU)
- Lifting of winds from 10 m to hub-height – research in progress
- Wind farm wake observed from satellite will be used in EERA-DTOC project to compare to wind farm wake model results